WHAT IS CLAIMED IS:

1. A cold-rolled steel sheet having excellent strain age hardenability comprising a composition, by mass %, comprising:

C: 0.15% or less;

Si: 1.0% or less;

Mn: 2.0% or less;

P: 0.1% or less;

S: 0.01% or less;

Al: 0.005 to 0.030%; and

N: 0.0050 to 0.0400%;

wherein N/Al is 0.30 or more, the amount of dissolved N is 0.0010% or more, and the balance is composed of Fe and inevitable impurities.

2. A cold-rolled steel sheet having excellent strain age hardenability according to Claim 1, comprising a composition, by mass %, further comprising at least one of the following groups a to d:

Group a: at least one of Cu, Ni, Cr and Mo in a total of 1.0% or less;

Group b: at least one of Nb, Ti and V in a total of

0.1% or less;

Group c: 0.0030% or less of B; and

Group d: one or both of Ca and REM in a total of 0.0010 to 0.010%.

3. A cold-rolled steel sheet having excellent strain age hardenability comprising a composition, by mass %, comprising:

C: less than 0.01%;

Si: 0.005 to 1.0%;

Mn: 0.01 to 1.5%;

P: 0.1% or less;

S: 0.01% or less;

Al: 0.005 to 0.030%; and

N: 0.005 to 0.040%;

wherein N/Al is 0.30 or more, the amount of dissolved N is 0.0010% or more, and the balance is composed of Fe and inevitable impurities.

4. A cold-rolled steel sheet having excellent strain age hardenability according to Claim 3, wherein the composition, by mass %, preferably further comprises:

B: 0.0001 to 0.0030%; and

Nb: 0.005 to 0.050%;

wherein the ranges of B and Nb satisfy the following equations (1) and (2), and the balance is substantially composed of Fe:

$$N\% \geq 0.0015 + 14/93 \cdot Nb\% + 14/27 \cdot Al\% + 14/11 \cdot B\% \quad \ldots (1)$$

$$C\% \leq 0.5 \cdot (12/93) \cdot Nb\% \quad \ldots (2)$$

5. A cold-rolled steel sheet having excellent strain age hardenability according to Claim 3 or 4, wherein the composition, by mass %, further comprises at least one of Cu, Ni and Mo in a total of 1.0% or less.

6. A cold-rolled steel sheet having excellent strain age hardenability according to Claims 1 to 5, wherein the steel sheet has a crystal grain diameter of 20 μm or less.

7. A cold-rolled steel sheet having excellent strain age hardenability according to Claims 1 to 6, wherein strength after forming is increased by 60 MPa or more by heat treatment in a low temperature region of 120 to 200°C.

8. An electro-galvanized, hot-dip galvanized or alloyed hot-dip galvanized steel sheet having excellent strain age hardenability comprising a coated layer formed on the surface of a cold-rolled steel sheet according to Claims 1 to 7 by electro-galvanization, hot-dip galvanization, or alloying hot-dip galvanization.

9. A method of producing a cold-rolled steel sheet having excellent strain age hardenability comprising hot-rolling a steel slab under conditions in which the steel slab is cooled immediately after the end of finish rolling and coiled at a coiling temperature of 400 to 800°C, cold-rolling the hot-rolled sheet with a rolling reduction ratio of 60 to 95%, and then recrystallizing and annealing the cold-rolled sheet at a temperature of 650 to 900°C, wherein the steel slab has a composition, by mass %, comprising:

C: less than 0.01%;

Si: 0.005 to 1.0%;

Mn: 0.01 to 1.5%;

P: 0.1% or less;

S: 0.01% or less;

Al: 0.005 to 0.030%; and

N: 0.005 to 0.040%;

wherein N/Al is 0.30 or more, and the balance is substantially composed of Fe.

10. A method of producing a cold-rolled steel sheet having excellent strain age hardenability according to Claim 9, wherein the composition, by mass %, further comprises:

B: 0.0001 to 0.0030%; and

Nb: 0.005 to 0.050%;

wherein the ranges of B and Nb satisfy the following equations (1) and (2), and the balance is substantially composed of Fe:

$$N\% \geq 0.0015 + 14/93 \cdot Nb\% + 14/27 \cdot Al\% + 14/11 \cdot B\% \quad \ldots (1)$$

$$C\% \leq 0.5 \cdot (12/93) \cdot Nb\% \quad \ldots (2)$$

11. A method of producing a cold-rolled steel sheet having excellent strain age hardenability according to Claim 9 or 10, wherein in the heating-up step in the recrystallization annealing, the temperature is increased at a rate of 1 to 20°C/s in the temperature region from

500°C to the recrystallization temperature.

12. A method of producing an galvannealed steel sheet having excellent strain age hardenability comprising hot-dip galvanization and then heat alloying after recrystallization and annealing according to Claims 9 to 11.

13. A cold-rolled deep drawing steel sheet having excellent strain age hardenability comprising a composition, by mass %, comprising:

C: 0.01% or less;

Si: 1.0% or less;

Mn: 0.01 to 1.5%;

P: 0.1% or less;

S: 0.01% or less;

Al: 0.005 to 0.020%; and

N: 0.0050 to 0.040%;

wherein N/Al is 0.30 or more, the amount of dissolved N is 0.0010% or more, the balance is composed of Fe and inevitable impurities, and Ts x r value is 750 MPa or more.

14. A cold-rolled deep drawing steel sheet having excellent strain age hardenability according to Claim 13, wherein the composition, by mass %, further comprises:

B: 0.0001 to 0.0030%; and

Nb: 0.005 to 0.050%;

wherein the balance is composed of Fe and inevitable impurities, TS x r value is 750 MPa or more, and the ranges of B and Nb satisfy the following equations (1) and (2),:

$$N\% \geq 0.0015 + 14/93 \cdot Nb\% + 14/27 \cdot Al\% + 14/11 \cdot B\% \quad \ldots (1)$$

$$C\% \leq 0.5 \cdot (12/93) \cdot Nb\% \quad \ldots (2)$$

15. A cold-rolled deep drawing steel sheet having excellent strain age hardenability according to Claim 13, wherein the composition, by mass %, further comprises at least one of the following:

B: 0.0001 to 0.0030%;

Nb: 0.005 to 0.050%;

Ti: 0.005 to 0.070%; and

V: 0.005 to 0.10%;

wherein N/(Al+Nb+Ti+V+B) is 0.30 or more, the amount of dissolved N is 0.0010% or more, the balance is composed

of Fe and inevitable impurities, and TS x r value is 750 MPa or more.

16. A method of producing a cold-rolled deep drawing steel sheet having excellent strain age hardenability comprising heating a steel raw material to 950°C or more, roughly rolling the raw material so that the finisher delivery temperature is Ar_3 to 1000°C, finish-rolling the material while lubricating it in the temperature region of 600°C to Ar_3, coiling the rolled sheet in which the total reduction by rolling starting from rough rolling to finish rolling is 80% or more, recrystallizing and annealing the hot-rolled sheet, cold-rolling the rolled sheet with a rolling reduction of 60 to 95%, and then recrystallizing and annealing the resultant cold-rolled sheet, wherein the steel raw material has a composition, by mass %, comprising:

C: less than 0.01%;

Si: 0.005 to 1.0%;

Mn: 0.01 to 1.5%;

P: 0.1% or less;

S: 0.01% or less;

Al: 0.005 to 0.030%;

N: 0.005 to 0.040%; and

at least one of the following:

B: 0.0003 to 0.0030%;

Nb: 0.005 to 0.050%;

Ti: 0.005 to 0.070%; and

V: 0.005 to 0.10%;

wherein N/(Al+Nb+Ti+V+B) is 0.30 or more.

17. A high-tensile-strength cold-rolled steel sheet having excellent moldability, strain age hardenability and natural aging resistance comprising a composition, by mass %, comprising:

C: 0.0015 to 0.025%;

Si: 1.0% or less;

Mn: 2.0% or less;

P: 0.1% or less;

S: 0.02% or less;

Al: 0.02% or less;

N: 0.0050 to 0.0250%; and

one or both of the following:

B: 0.0001 to 0.0050%; and

Nb: 0.002 to 0.050%;

wherein N/Al is 0.30 or more, the amount of dissolved N is 0.0010% or more, the balance is composed of Fe and inevitable impurities, the structure is composed of an acicular ferrite phase at an area ratio of 5% or more and a ferrite phase having an average crystal grain diameter of 20 μm or less, and the r value is 1.2 or more.

18. A cold-rolled steel sheet according to Claim 17, wherein the composition further comprises at least one of the following groups a to c:

Group a: at least one of Cu, Ni, Cr and Mo in a total of 1.0% or less;

Group b: one or both of Ti and V in a total of 0.1% or less; and

Group c: one or both of Ca and REM in a total of 0.0010 to 0.010%.

19. A method of producing a high-tensile-strength cold-rolled steel sheet having a r value of 1.2 or more, and excellent moldability, strain age hardenability and natural aging resistance comprising:

the hot-rolling step of roughly rolling a steel slab by heating to a slab heating temperature of 1000°C or more to form a sheet bar, finish-rolling the sheet bar so that the finisher delivery temperature is 800°C or more, and coiling the finish-rolled sheet at a coiling temperature of 800°C or less to form a hot-rolled sheet;

the cold rolling step of pickling and cold-rolling the hot-rolled sheet to form a cold-rolled sheet; and

the cold-rolled sheet annealing step of continuously annealing the cold-rolled sheet at a temperature in the ferrite-austenite two-phase region, and cooling the annealed sheet to the temperature region of 500°C or less at a cooling rate of 10 to 300°C/s;

wherein the steel slab has a composition, by mass %, comprising at least one of:

C: 0.0015 to 0.025%;

Si: 1.0% or less;

Mn: 2.0% or less;

P: 0.1% or less;

S: 0.02% or less;

Al: 0.02% or less;

N: 0.0050 to 0.0250%; and

at least one of the following:

B: 0.0001 to 0.0050%; and

Nb: 0.002 to 0.050%;

wherein N/Al is 0.30 or more.

20. A method of producing a cold-rolled steel sheet according to Claim 19, wherein the composition further comprises, by mass %, at least one of the following groups a to c:

Group a: at least one of Cu, Ni, Cr and Mo in a total of 1.0% or less;

Group b: one or both of Ti and V in a total of 0.1% or less; and

Group c: one or both of Ca and REM in a total of 0.0010 to 0.010%.

21. A high-tensile-strength cold-rolled steel sheet having a high r value and excellent strain age hardenability and natural aging resistance comprising a composition, by mass %, comprising:

C: 0.025 to 0.15%;

Si: 1.0% or less;

Mn: 2.0% or less;

P: 0.08% or less;

S: 0.02% or less;

Al: 0.02% or less; and

N: 0.0050 to 0.0250%;

wherein N/Al is 0.30 or more, the amount of dissolved N is 0.0010% or more, the balance is composed of Fe and inevitable impurities, the structure is composed of a ferrite phase having an average crystal grain diameter of 10 μm or less at an area ratio of 80% or more and a martensite phase as a second phase at an area ratio of 2% or more, and the r value is 1.2 or more.

22. A high-tensile-strength cold-rolled steel sheet according to Claim 21, wherein the composition further comprises at least one of the following groups d to g:

Group d: at least one of Cu, Ni, Cr and Mo in a total of 1.0% or less;

Group e: at least one of Nb, Ti and V in a total of 0.1% or less;

Group f: 0.0030% or less of B; and

Group g: one or both of Ca and REM in a total of

0.0010 to 0.010%.

23. A method of producing a high-tensile-strength cold-rolled steel sheet having a r value of as high as 1.2 or more, and excellent strain age hardenability and natural aging resistance comprising:

the hot-rolling step of roughly rolling a steel slab by heating to a slab heating temperature of 1000°C or more to form a sheet bar, finish-rolling the sheet bar so that the finisher delivery temperature is 800°C or more, and coiling the finish-rolled sheet at a coiling temperature of 800°C or less to form a hot-rolled sheet;

the cold rolling step of pickling and cold-rolling the hot-rolled sheet to form a cold-rolled sheet; and

the cold-rolled sheet annealing step of box-annealing the cold-rolled sheet at an annealing temperature of the recrystallization temperature to 800°C, then continuously annealing the annealed sheet at an annealing temperature of Ac_1 transformation point to Ac_3 transformation point - 20°C), and then cooling the sheet to the temperature region of 500°C or less at a cooling rate of 10 to 300°C/s;

wherein the steel slab has a composition, by mass %, comprising at least one of:

C: 0.025 to 0.15%;

Si: 1.0% or less;

Mn: 2.0% or less;

P: 0.08% or less;

S: 0.02% or less;

Al: 0.02% or less; and

N: 0.0050 to 0.0250%;

wherein N/Al is 0.30 or more.

24. A method of producing a high-tensile-strength cold-rolled steel sheet according to Claim 23, further comprising performing over aging in a temperature region of 350°C to the cooling step temperature for a residence tine of 20 seconds or more subsequent to cooling after the continuous annealing.

25. A method of producing a high-tensile-strength cold-rolled steel sheet according to Claim 23 or 24, wherein the composition further comprises, by mass %, at least one of the following groups d to g:

Group d: at least one of Cu, Ni, Cr and Mo in a total of 1.0% or less;

Group e: at least one of Nb, Ti and V in a total of 0.1% or less;

Group f: 0.0030% or less of B; and

Group g: one or both of Ca and REM in a total of 0.0010 to 0.010%.